CLAS Note 93-007

Aging Studies: Effect of Field Wire Diameter

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Abstract:

Aging studies were performed on three single-cell prototype drift chambers which differed only in choice of field wire; being 140μm gold-plated Aluminum, 100μm stainless steel, and 70μm stainless steel, respectively. With high voltages set to equalize gains, the three chambers were found to have equal background noise rates and equal rates when irradiated with an Fe^{55} test source. The gains and counting rates changed by less than 10% after an accumulated radiation dose of greater than 0.3 C/cm. No differences between chambers were observed.

Motivation:

We performed these studies to determine if chambers strung with smaller diameter field wire would age faster than those strung with large diameter wire. Previous studies of cathode emission from field wires (see CLAS-Note 92-016, "Minimizing Cathode Emission in Drift Chambers") had indicated that field wires of diameters between 70 and 140μm should be equivalent as far as aging was concerned when run at our nominal operating conditions. We wanted to directly test that assumption, as well as to have an indication of anything else in our set-up which might cause premature aging.

Experimental Setup:

Three chambers were built as close to identical as possible, except for the different field wire choice. See Figure 1 for a drawing of the chamber arrangement, as well as an indication of the region of wire exposed to X-rays. Each chamber had a central anode wire surrounded by six field wires, and outside of these, by six guard wires. The anode wire was 20μm gold-plated tungsten wire and the guard wires were 150μm stainless steel wire. The chambers were labelled 1, 2 and 3 and contained field wires of 140μm aluminum, 100μm steel or 70μm steel, respectively.

To minimize systematic differences betwee the chambers, the chambers were mounted in a single frame, stacked on top of one another and a 50:50 Argon:Ethane gas mixture flowed through them in parallel from a single input and output manifold. High voltage cables were moved from one chamber to another in turn as that chamber was operated. A single pre-amplifier package was used; being moved also from chamber to chamber.

Because of the different field wire diameters, the three chambers had different capacitances, and thus slightly different operating voltages to achieve equal gas gain. We equalized the gas gain on the chambers by adjusting the values of the high voltage to achieve equal pulse heights when irradiated by an Fe^{55} source. Table 1 lists the operating voltages of the three chambers and the electric field at the field wire surface.

Operating Voltages					
Chamber	Rad. (Field)	V(sense)	V(field)	V(guard)	E(field)
1	$140\mu m$	2180 V	-725 V	900 V	23 kV/cm
2	$100\mu m$	2225 V	-725 V	900 V	31 kV/cm
3	$70\mu m$	2250 V	-725 V	900 V	43 kV/cm

The output of the amplifiers was discriminated with a 20 mV threshold and the discriminator output was scaled. In general, we recorded the number of counts produced by our test Fe^{55} source in 10 seconds and the number of background counts (source removed) in a 30 second interval. Once the chambers were operational, the procedure was to move the high voltage and amplifier connections to the chamber to be irradiated, and to record the pulse height due to the Fe^{55} source as well as the scaled number of source and background counts. We then exposed the chamber to a collimated beam of 8 keV X-rays, recording the current drawn by the chamber as well as the pulse height.
We allowed the X-ray generator to irradiate the chamber in question for a period of one to four days, at which time we would record all of the above information and then move the X-ray generator to another chamber and repeat the procedure. We continued the experiment from Aug. 11 to Sept. 22, 1992 accumulating about 13 days of exposure on each chamber.

Results:

We integrated the current draw versus irradiation time to obtain the dose each chamber received, that is the accumulated charge collected from the sense wire, expressed in Coulombs. In Figure 2 we plot the Fe^{55} count rate versus dose for each of the chambers, while in Figure 3 we plot the background count rate versus dose. There is no apparent change with dose for either of the count rates, nor is there any apparent difference between chambers to an accuracy of about 10%. We also recorded pulse heights due to the Fe^{55} source or to the X-ray generator and observed no change of pulse height with increasing dosage for any of the three chambers; once again, to an accuracy of about 10%.

Conclusions:

From the size and position of the collimating slit, we estimate that the length of sense wire over which the charge was accumulated was between 1.3 and 2.0 cm in length. Thus, we can say that up to a dose of 0.3 C/cm there is no evidence for radiation damage in a prototype chamber similar to our Region 3 chambers, using a standard 50/50 Argon:Ethane gas mixture. We also note no gain loss or noise level increase even in the chamber with $70\mu m$ field wire diameter. We note that this chamber has electric fields at the surface of the field wires of about 40 kV/cm, higher than the canonical "20 kV/cm" rule of thumb, and yet displays no observable aging for the dosages studied here.

Acknowledgements:

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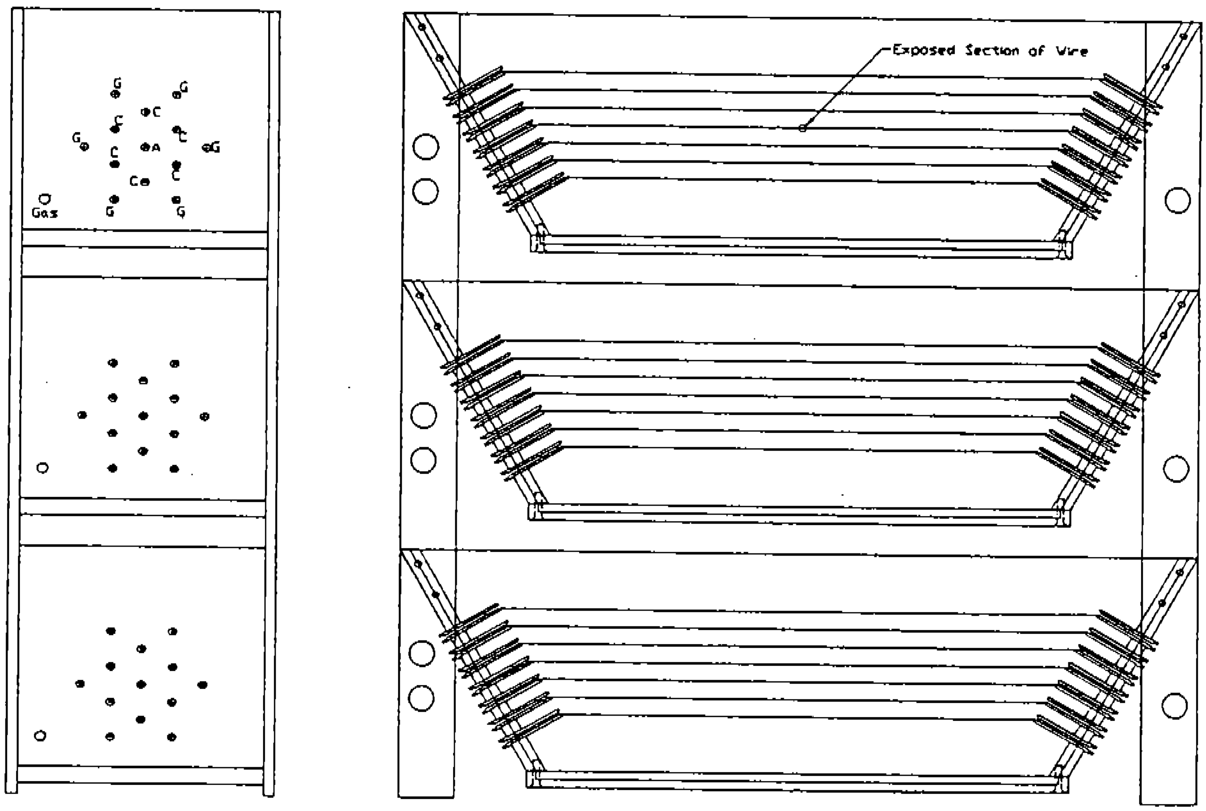

Figure 1: Schematic of the experimental apparatus, showing the three chambers stacked vertically atop one another. The end view shows the wire arrangement in the cell, with an anode wire surrounded by six field or cathode wires with six guard wires on the outside. The wire-to-wire spacing is 2 cm.

Figure 2: Count rate vs. dose (source on).

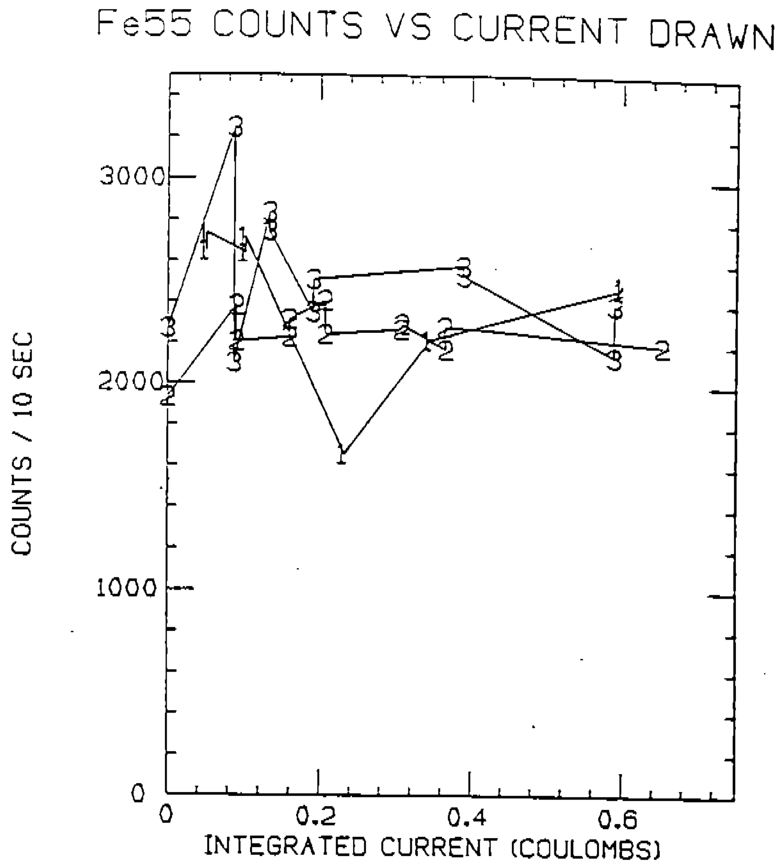

Figure 3: Count rate vs. dose (source off).